Radiometric and Spectral Consistency of Hyperspectral Infrared Sounders

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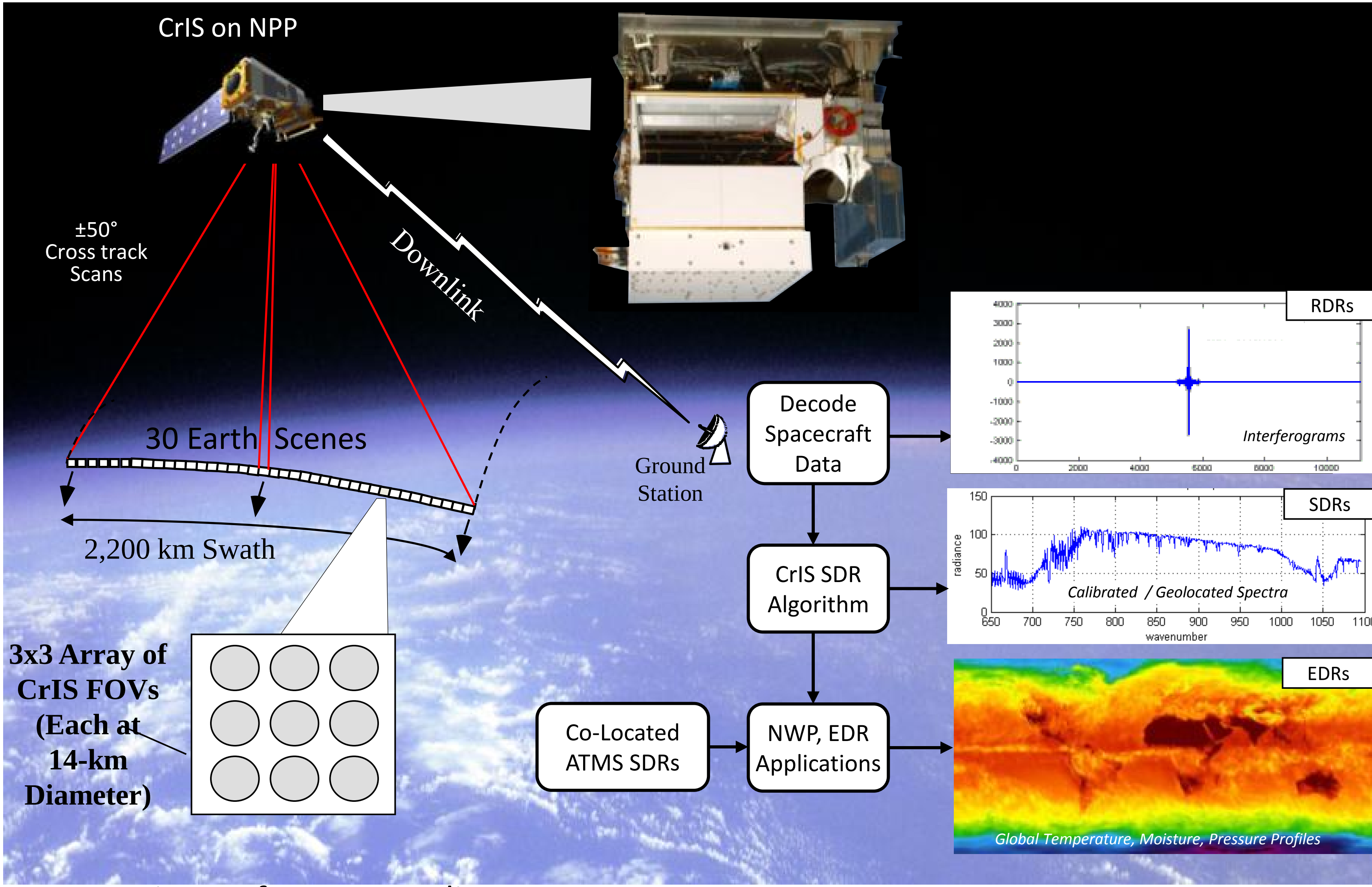
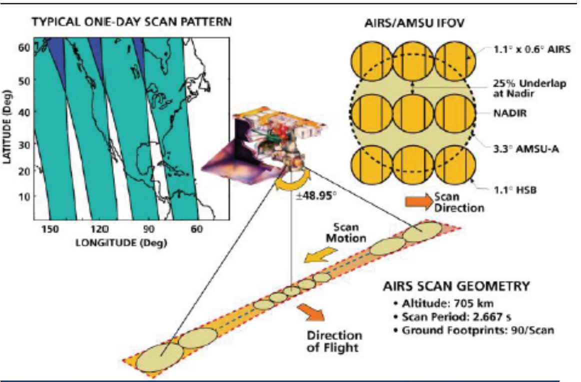
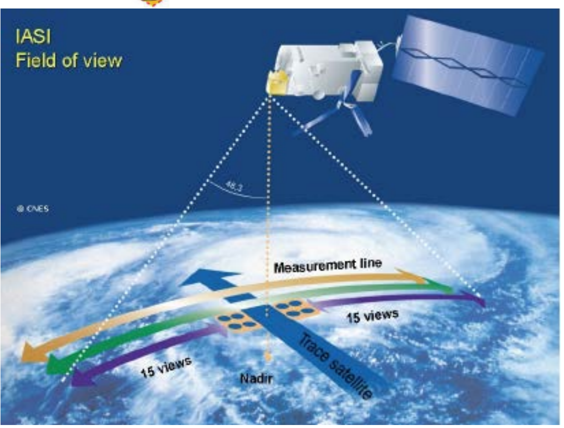
CrIS Operational Concept

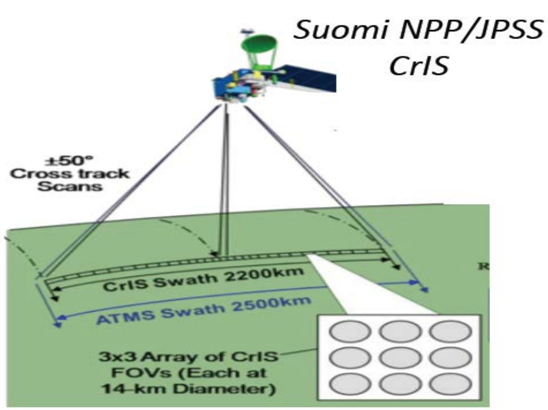


Figures from ITT Exelis

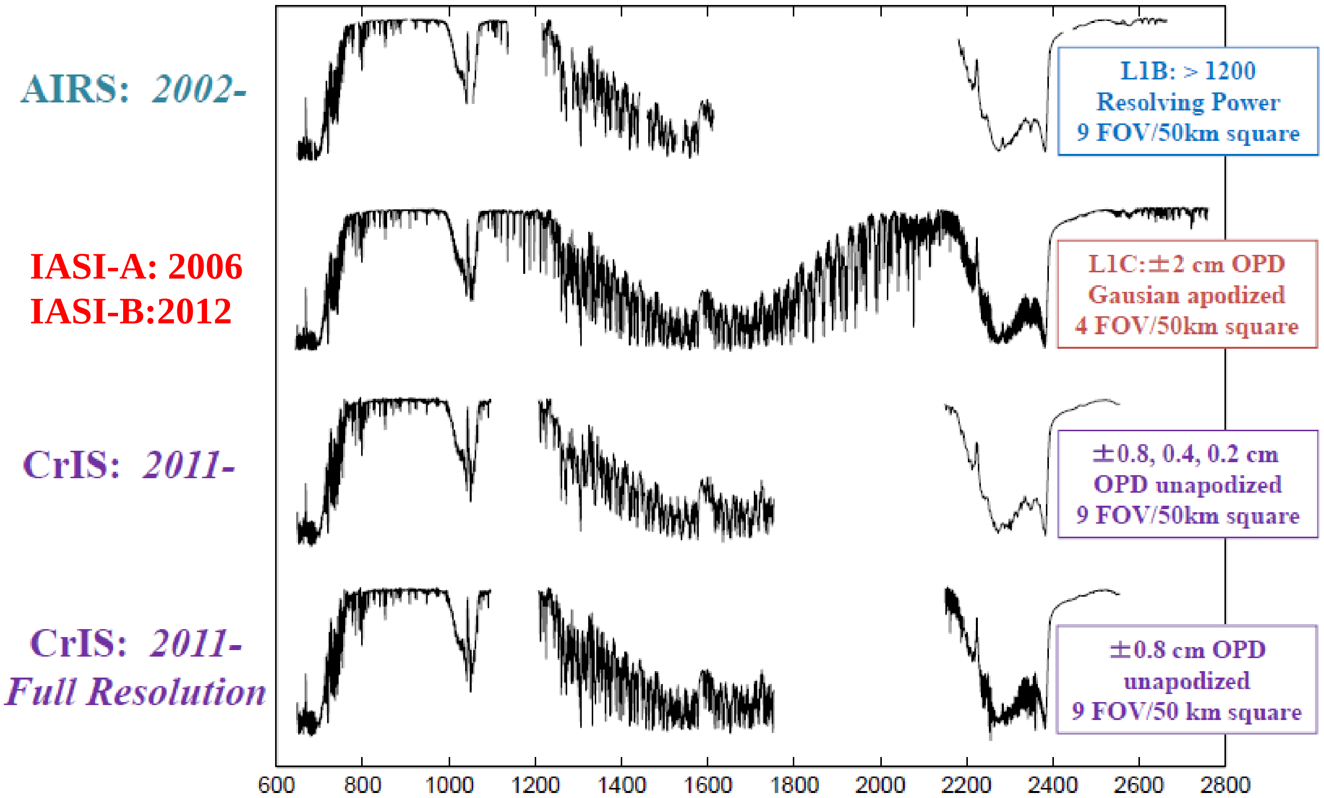
Instrument and Spectral Characteristics







Spectral Coverage and Resolution of AIRS, IASI, and CrIS



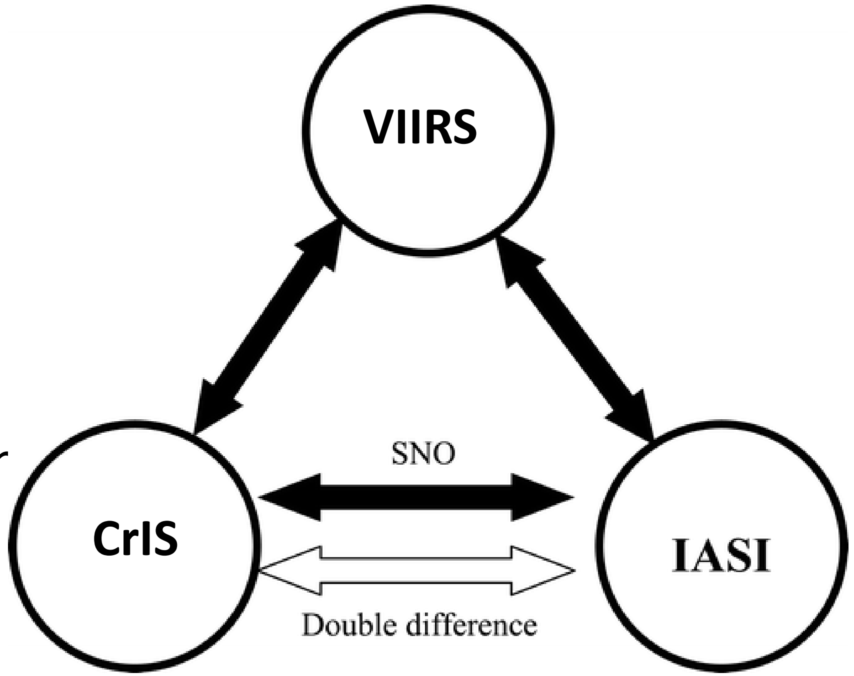
From Hank Revercomb

Motivation

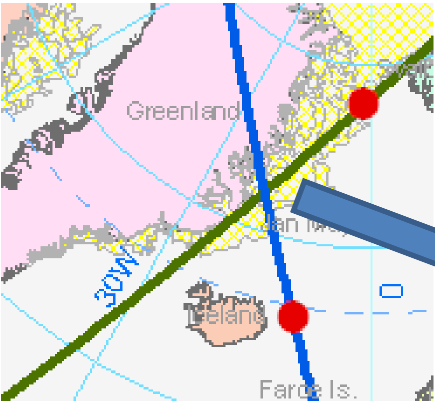
- Hyperspectral IR sounders have served as benchmark measurements for the GSICS community.
  - Polar orbiting sensor: HIRS, AVHRR, AATSR
  - Geostationary : Imagers and Sounders
- With more hyperspectral IR sounders on-orbit, are there any radiometric and spectral differences among them?
  - Now: AIRS →Metop-A/IASI → NPP/CrIS → Metop-B/IASI
  - Future: JPSS-1/CrIS and MetOp-C/IASI ….
- Understanding the root causes of the radiometric differences of these sounders will benefit for CrIS Cal/Val program

Approach

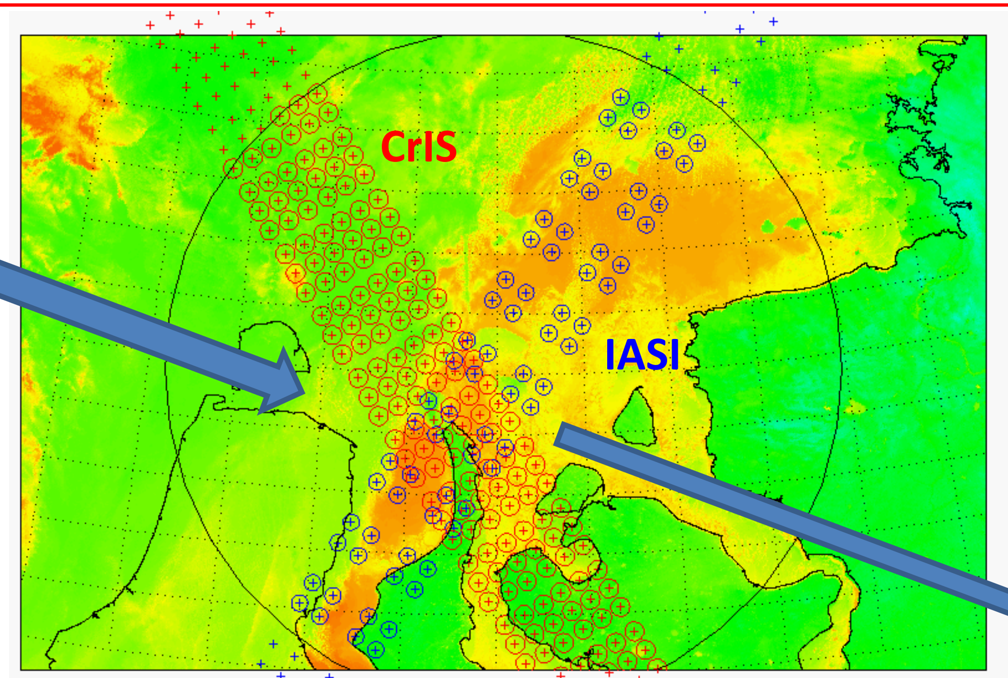
- Direct comparison
  - CrIS *versus* IASI (Metop-A and –B)
- Indirect comparison:
  - Through the third sensor, CrIS-VIIRS *versus* IASI-VIIRS
- Objectives
  - Reduce uncertainties caused by th methodology
  - Identify the differences at the sensor calibration level
  - Understanding the root causes of these differences



Simultaneous Nadir Overpass (SNO)



From Changyong Cao



Time Difference: <= 120 Sec

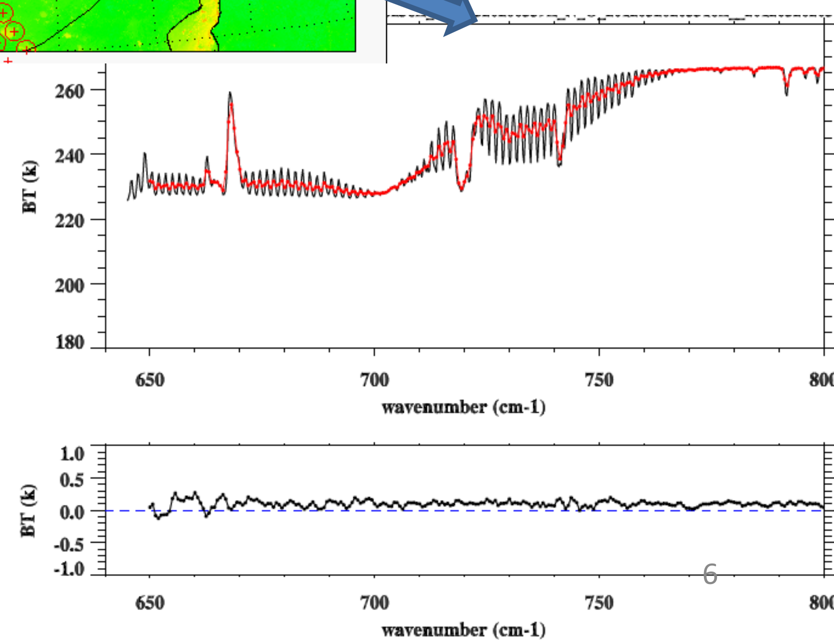
FOV distance difference: <=(12+14)/4.0 km = 6.5 km

Angle Difference: ABS(cos(a1)/cos(a2)-1) <= 0.01

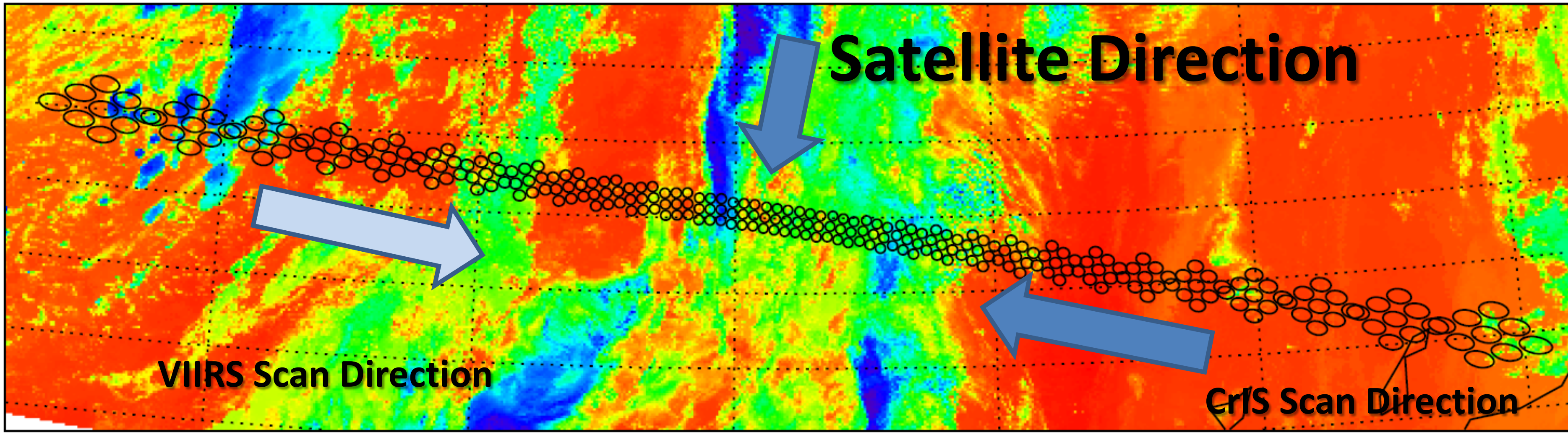
All data are from IDPS.

Only nadir and uniform scenes were selected.

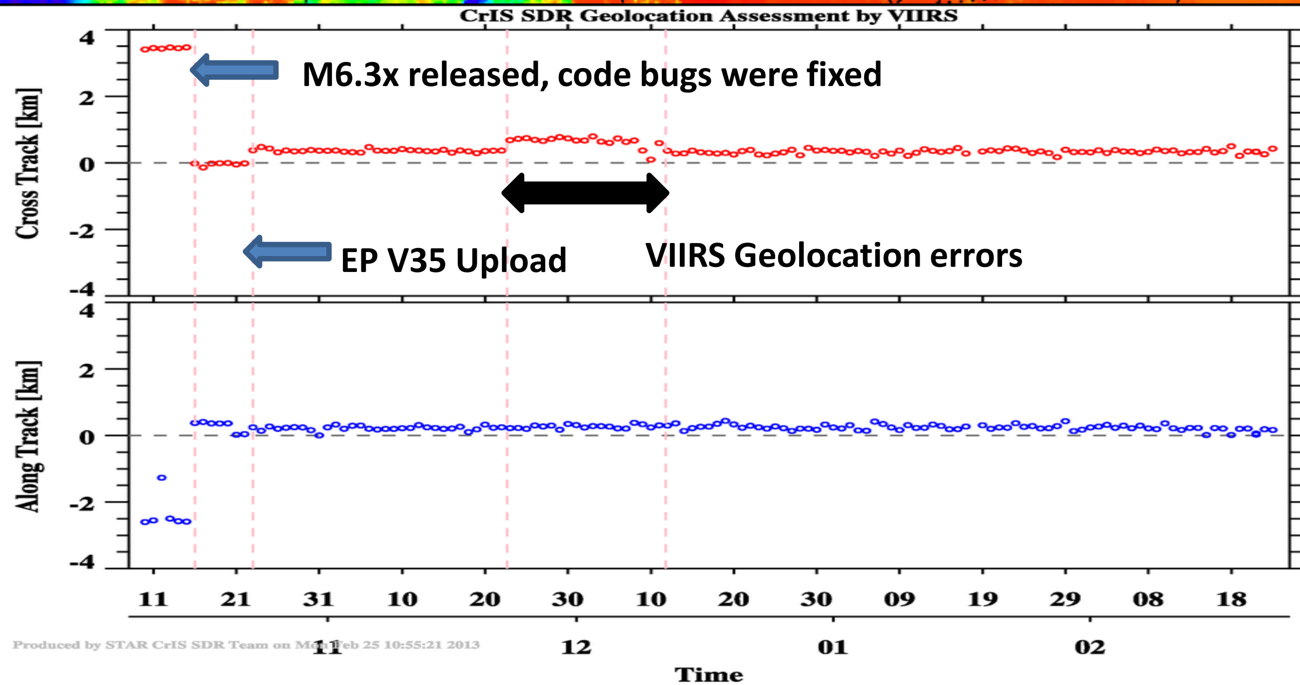
Using the same collocation algorithms to collocate CrIS/IASI with VIIRS.



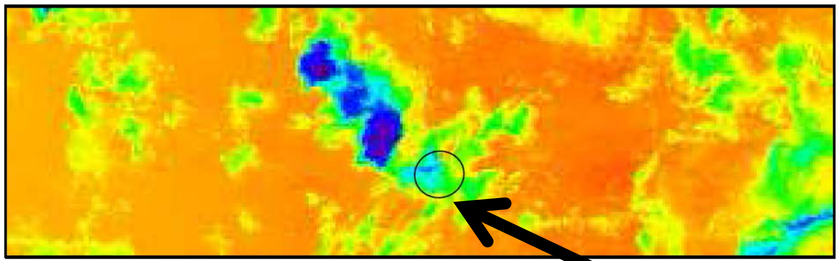
Collocating CrIS/IASI with VIIRS: Accurately computing FOV Shape



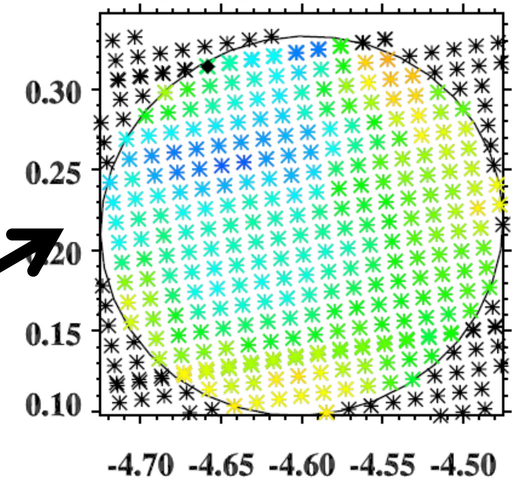
The method based on the algorithm can detect the VIIRS geolocation errors



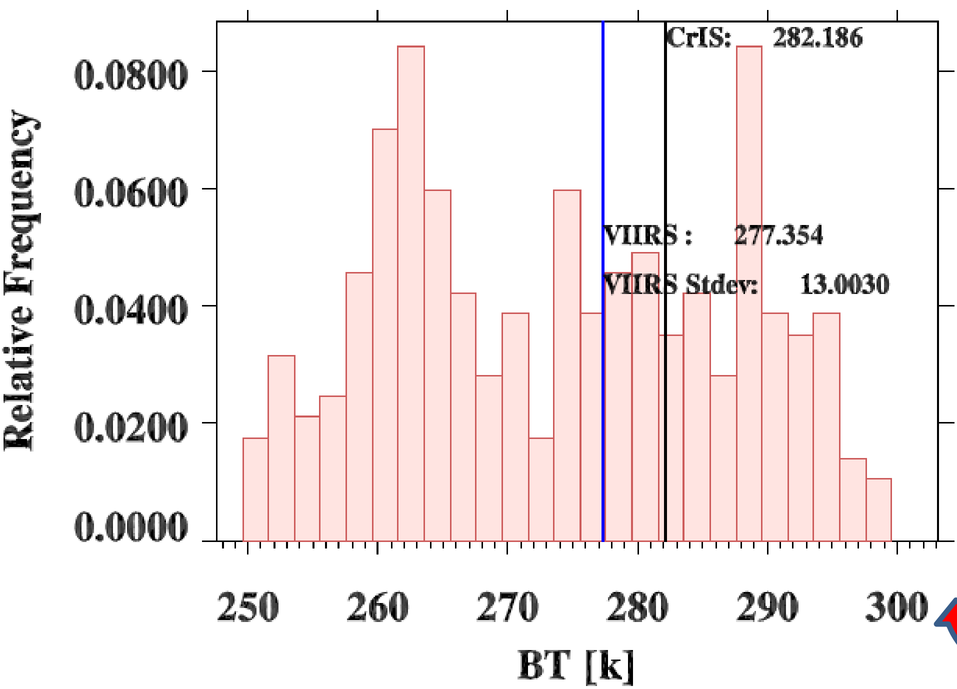
Collocate VIIRS with CrIS/IASI



VIIRS Pixels

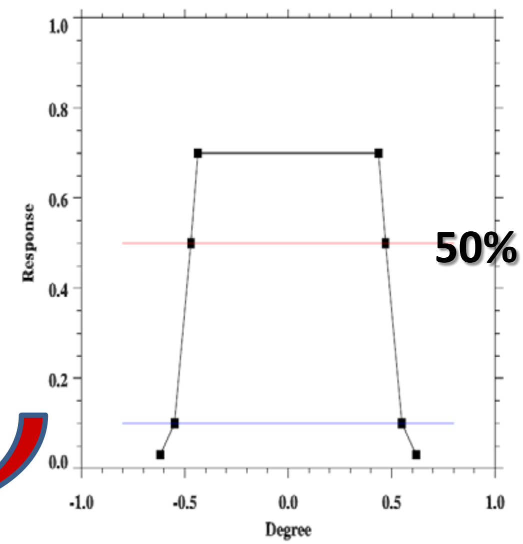


CrIS FOV footprint

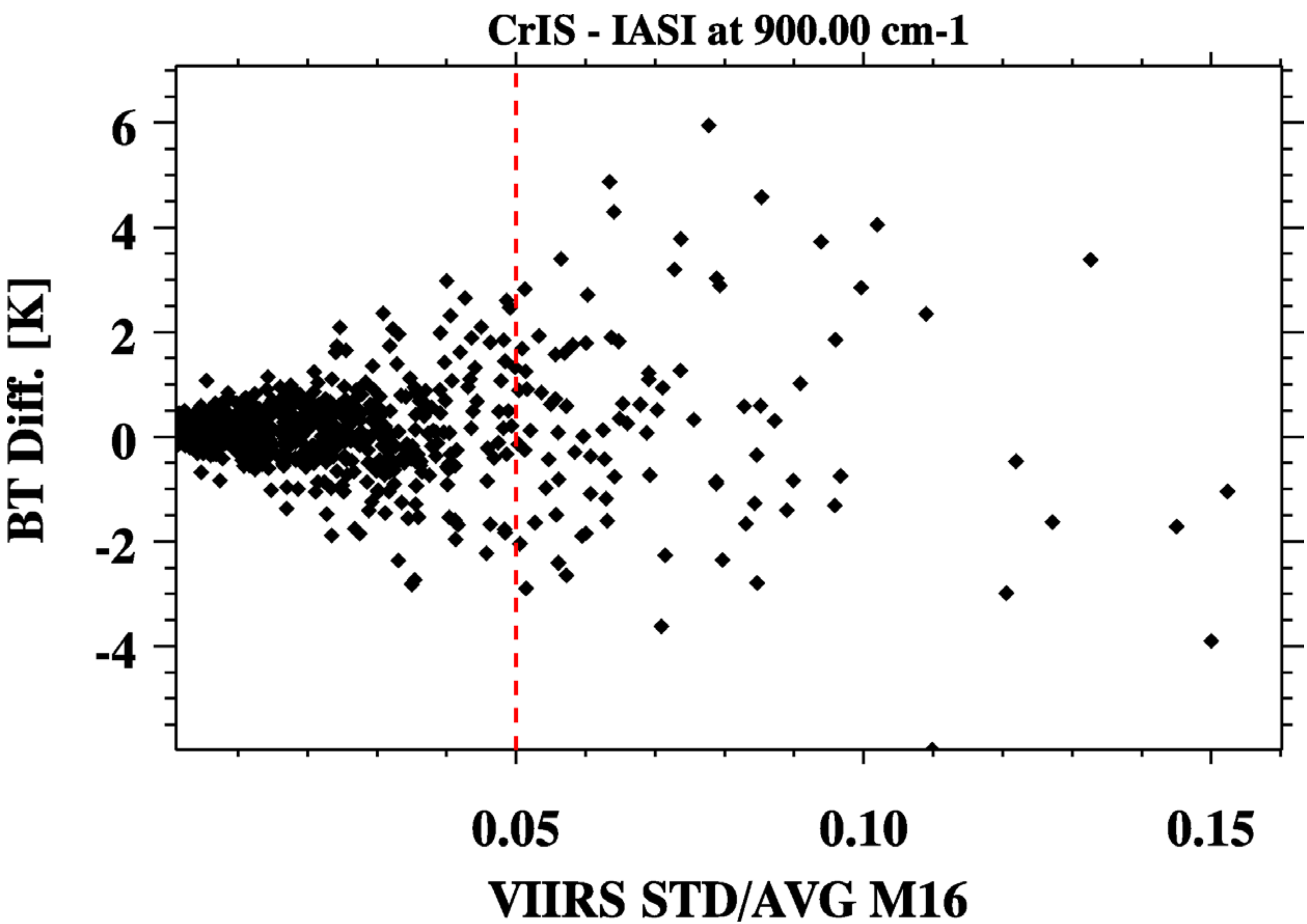


Histogram of VIIRS M16 radiances in CrIS FOV

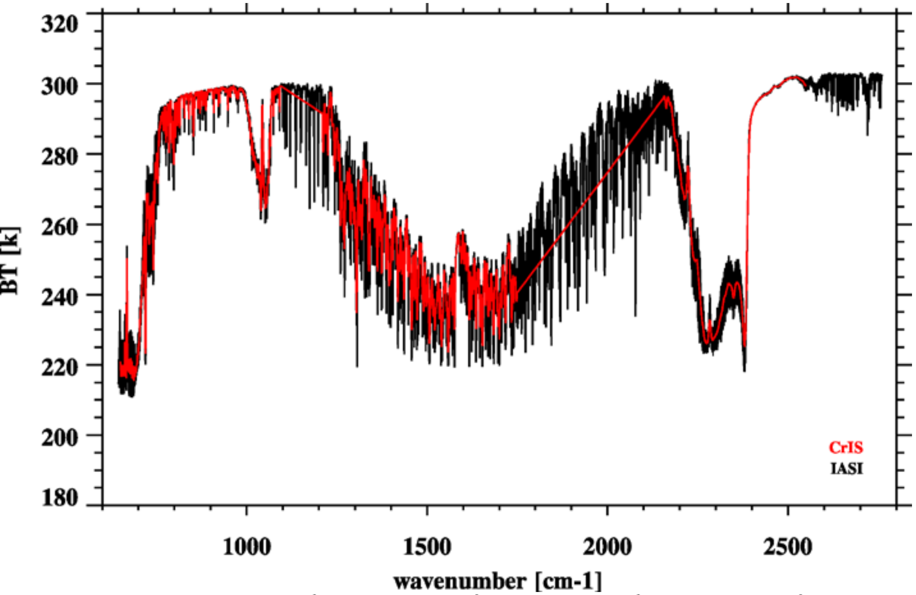
CrIS/IASI FOV Spatial Response



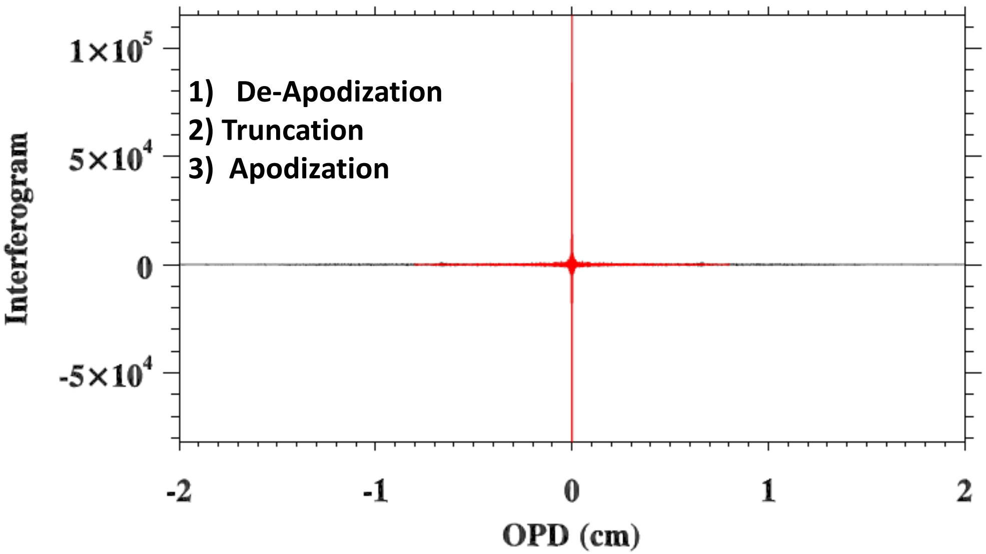
Scene Uniformity Effects

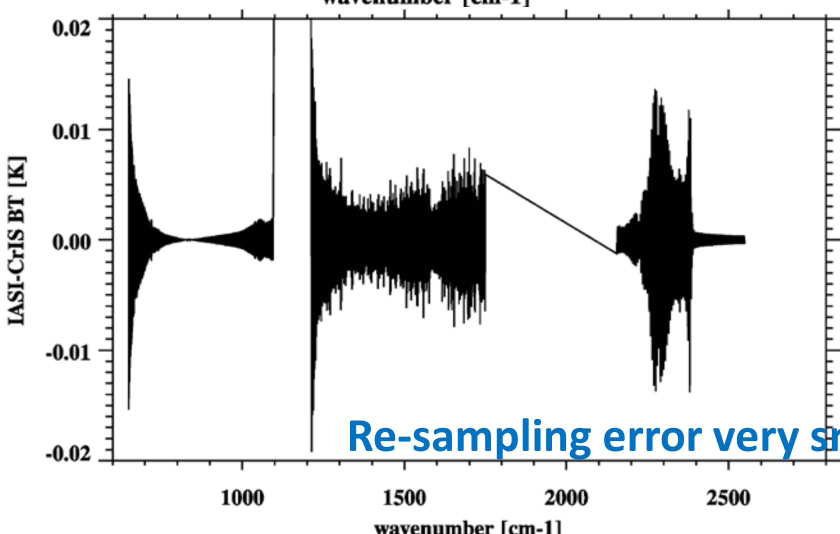


Resample IASI to CrIS



Fourier Transform





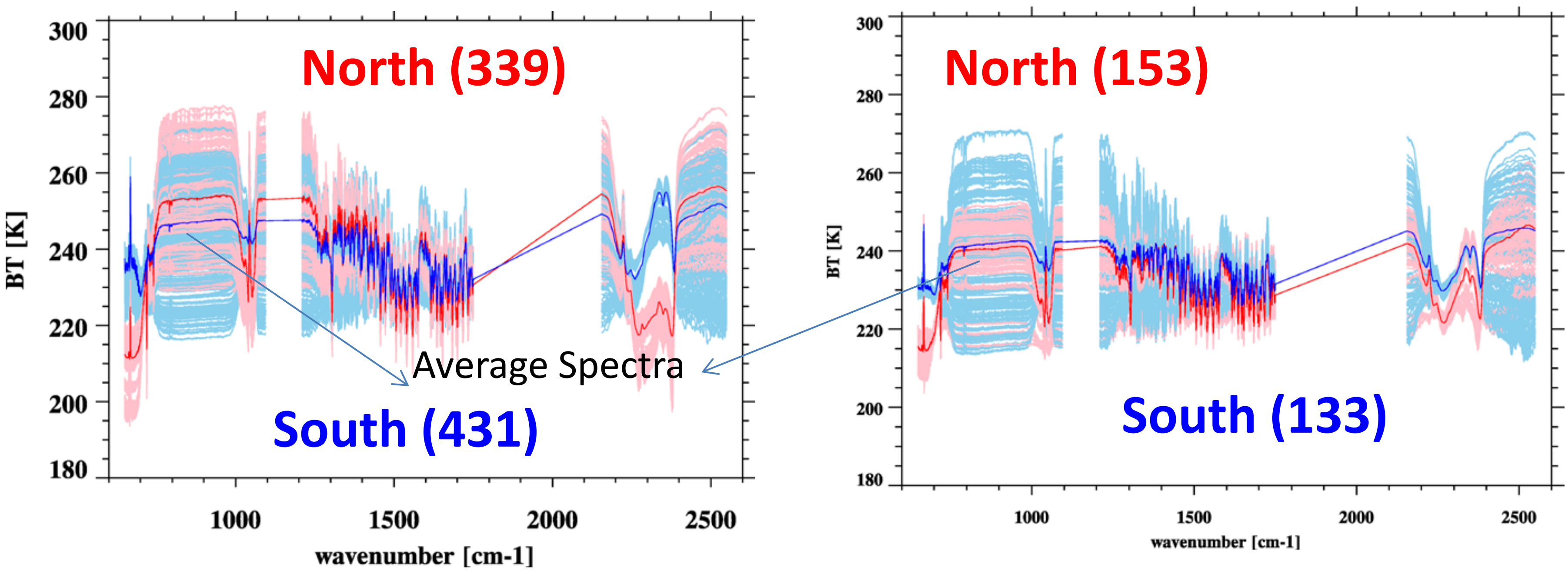
Re-sampling error very small

Inverse Fourier Transform

IASI and CrIS SNO Spectra

Metop-A IASI and CrIS

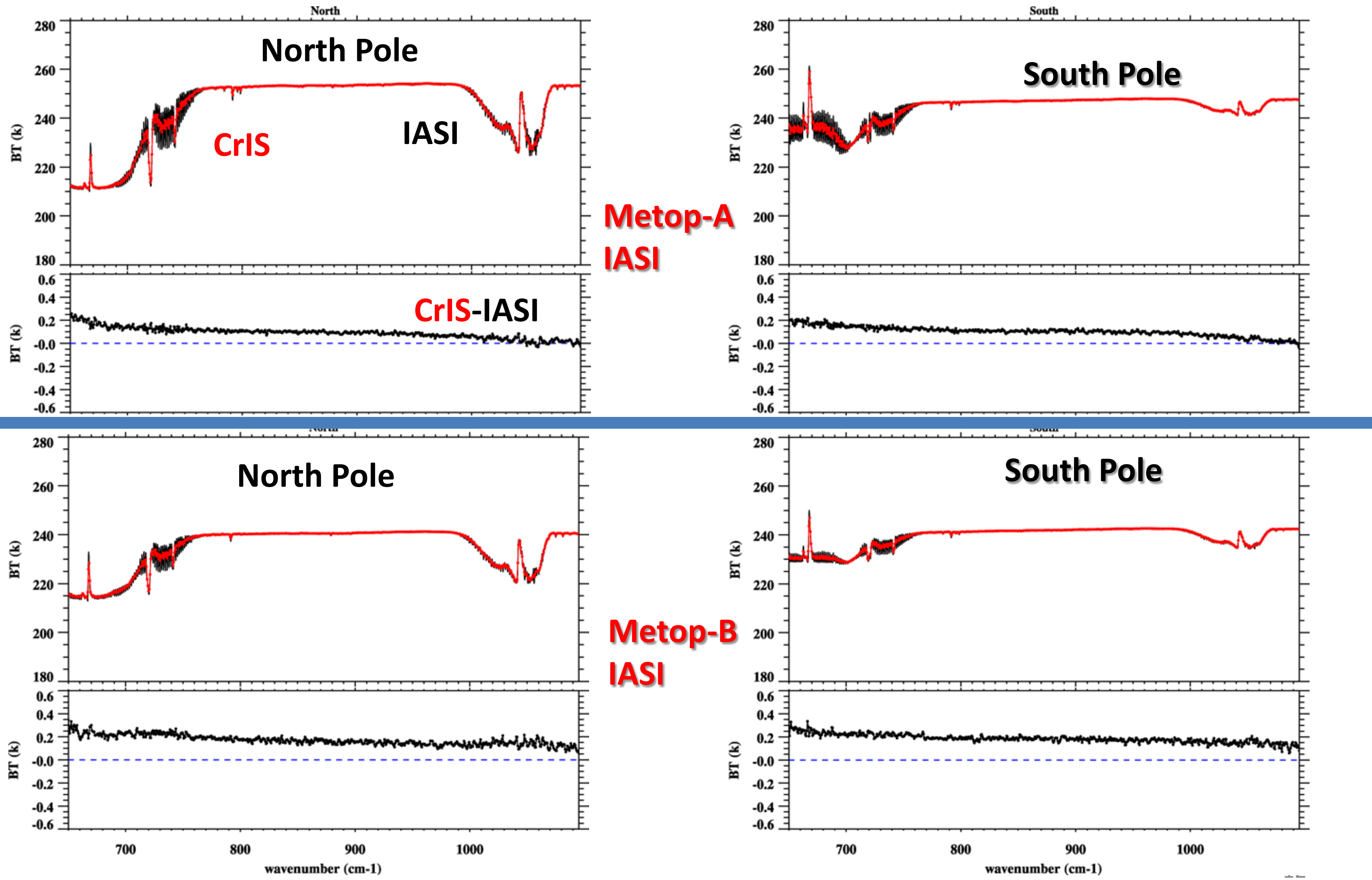
Metop-B IASI/ and CrIS



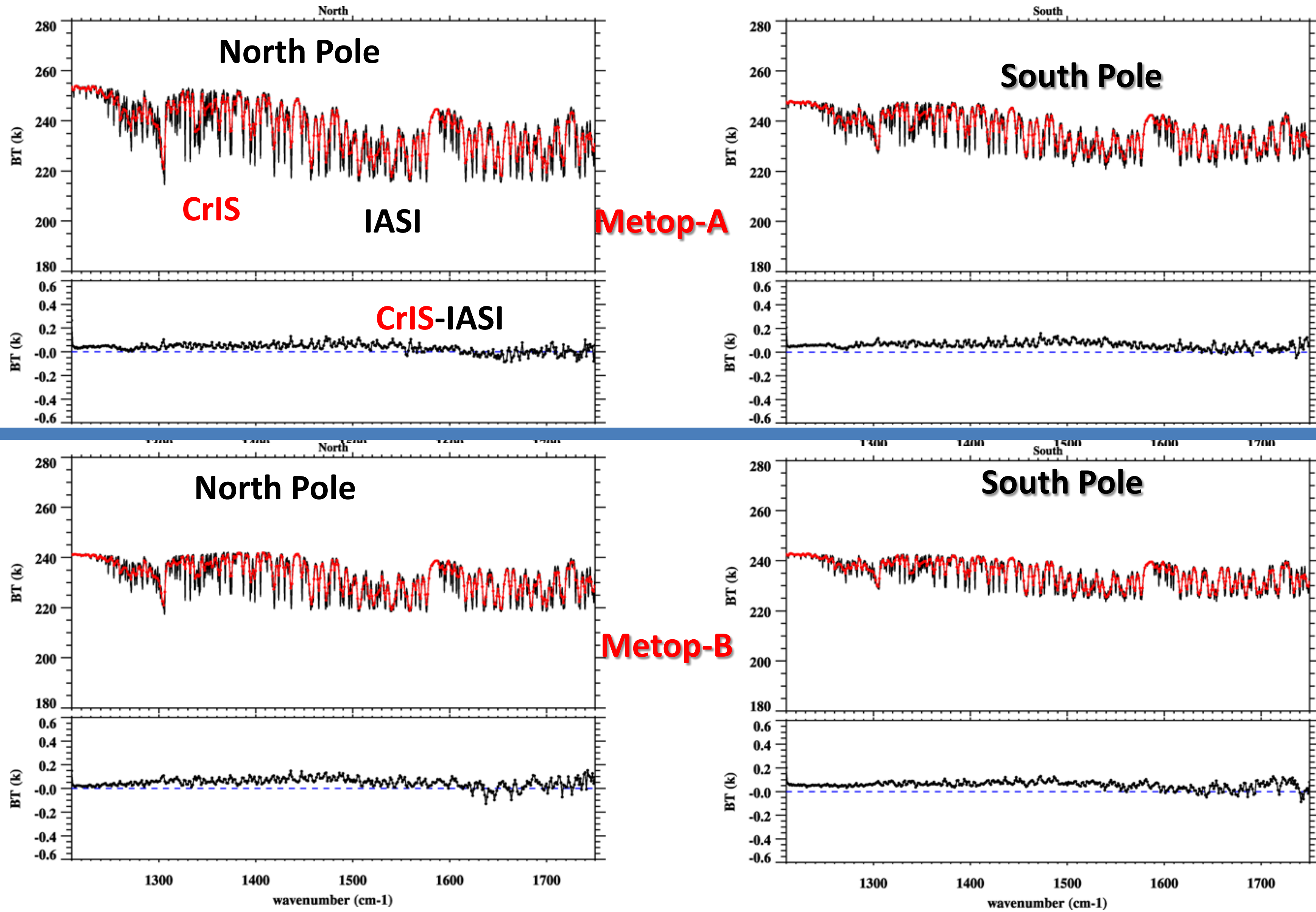
SNOs in 10/2012, 12/2012, and 02/2013

SNOs in 03/2013

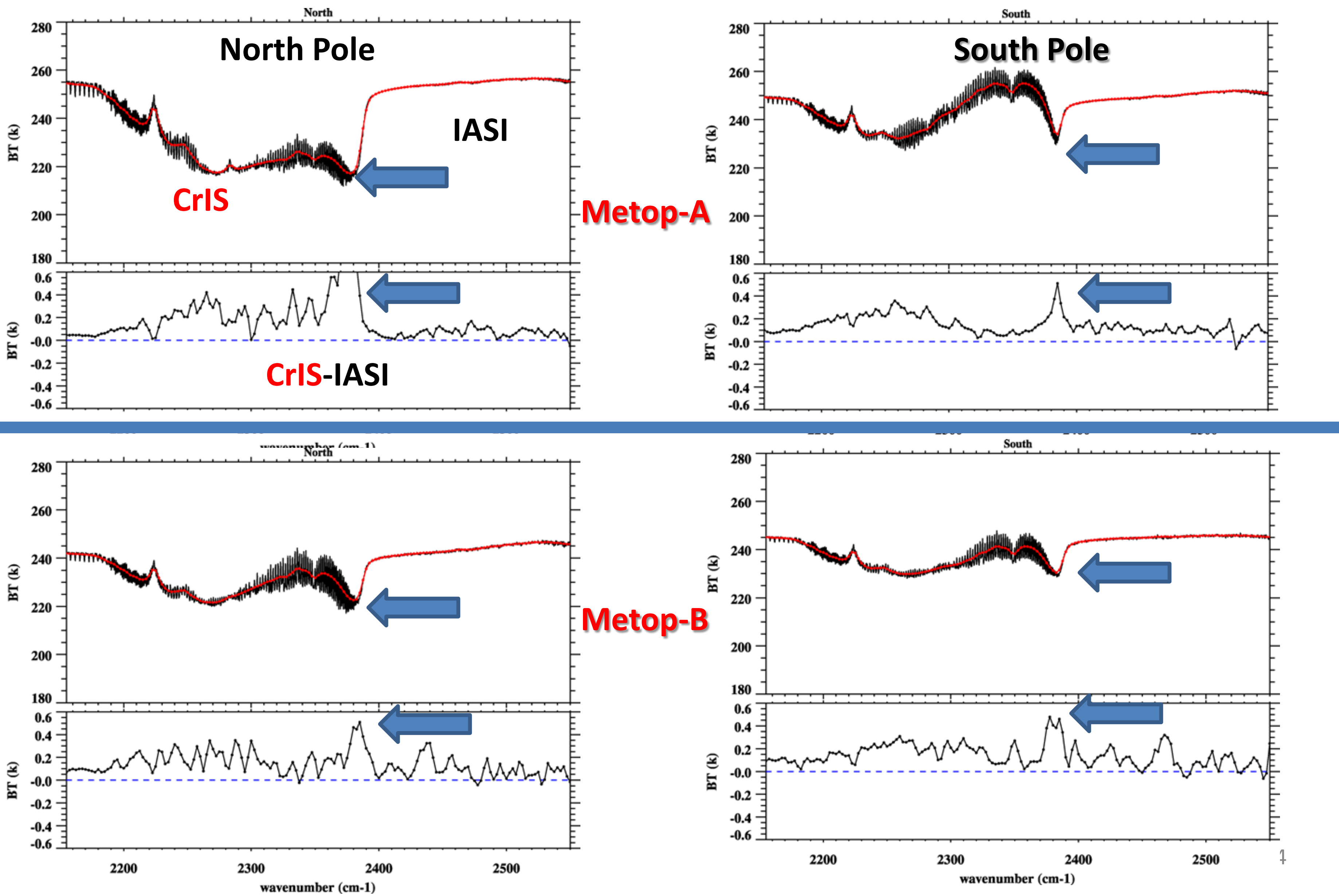
CrIS vs. IASI: CrIS Band 1



CrIS vs. IASI: CrIS Band 2



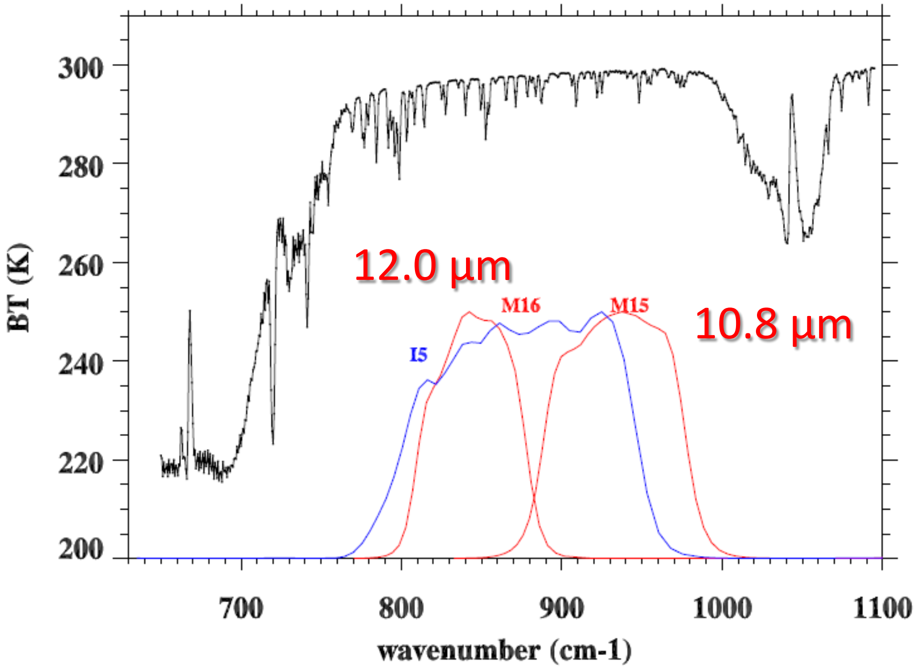
CrIS vs. IASI: CrIS Band 3

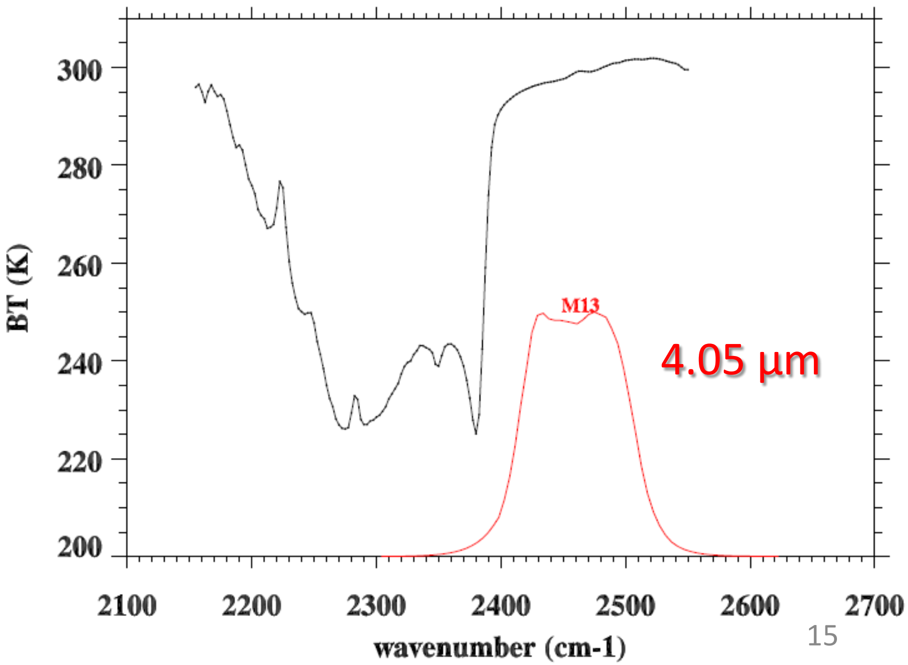


How about CrIS/IASI versus VIIRS?

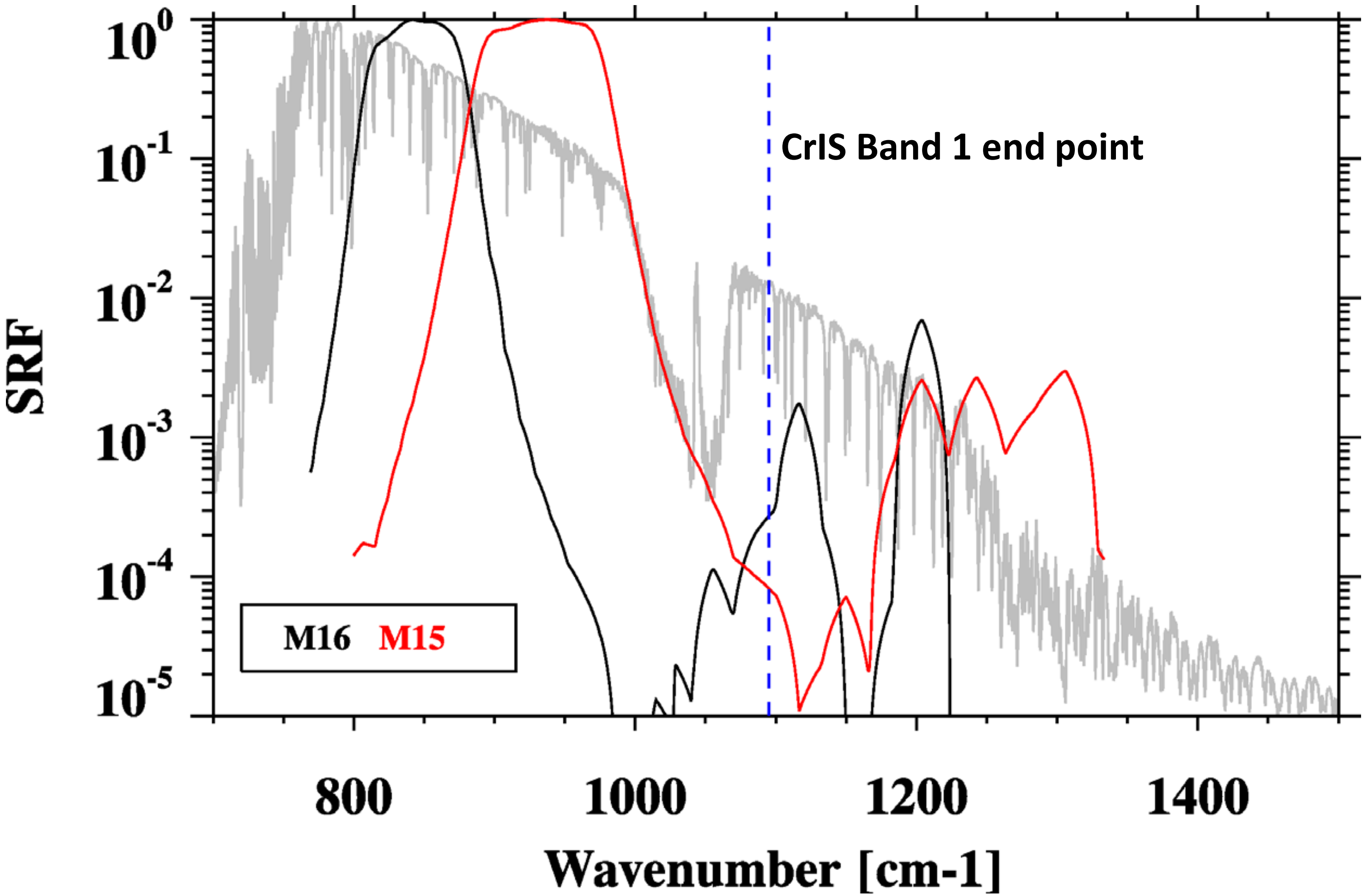
CrIS/IASI spectra are overlapped with VIIRS SRFs for M13, M15, and M16, and I5

$$L_i = \frac{\int_{\nu_1}^{\nu_2} R(\nu) S_i(\nu) d\nu}{\int_{\nu_1}^{\nu_2} S_i(\nu) d\nu}$$



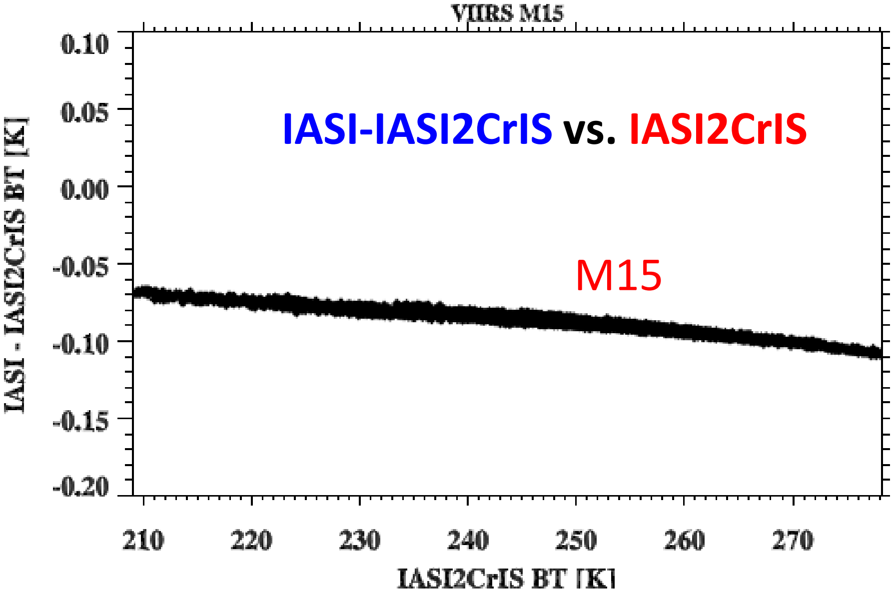


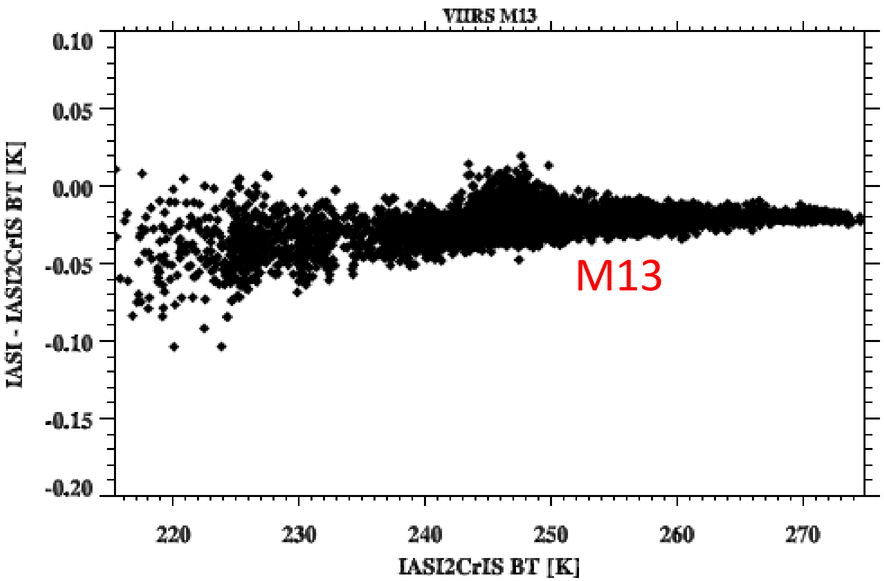
Be careful for out-of-band response!

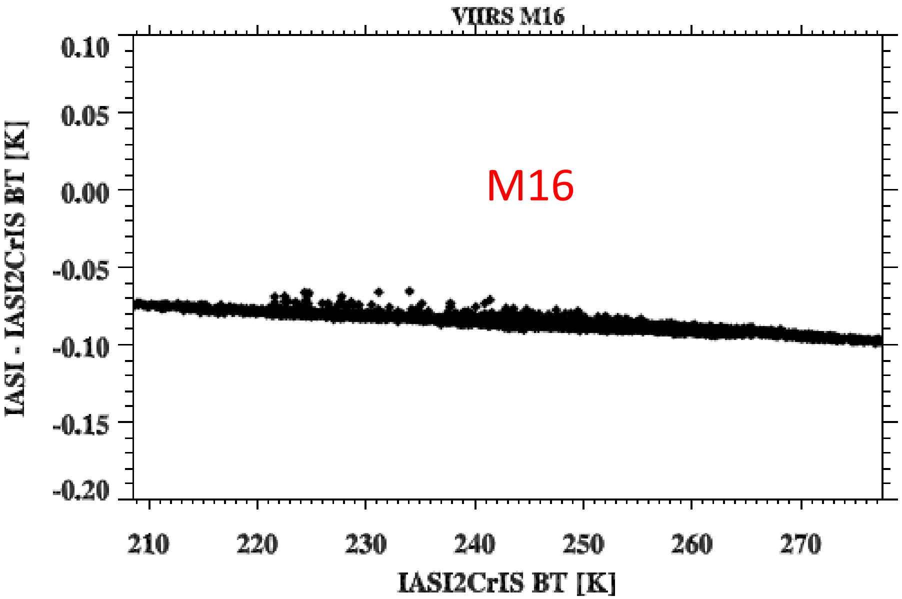


Center wavenumber and band correction coefficients are calculated using the above SRFs.

OOB effects in BTs

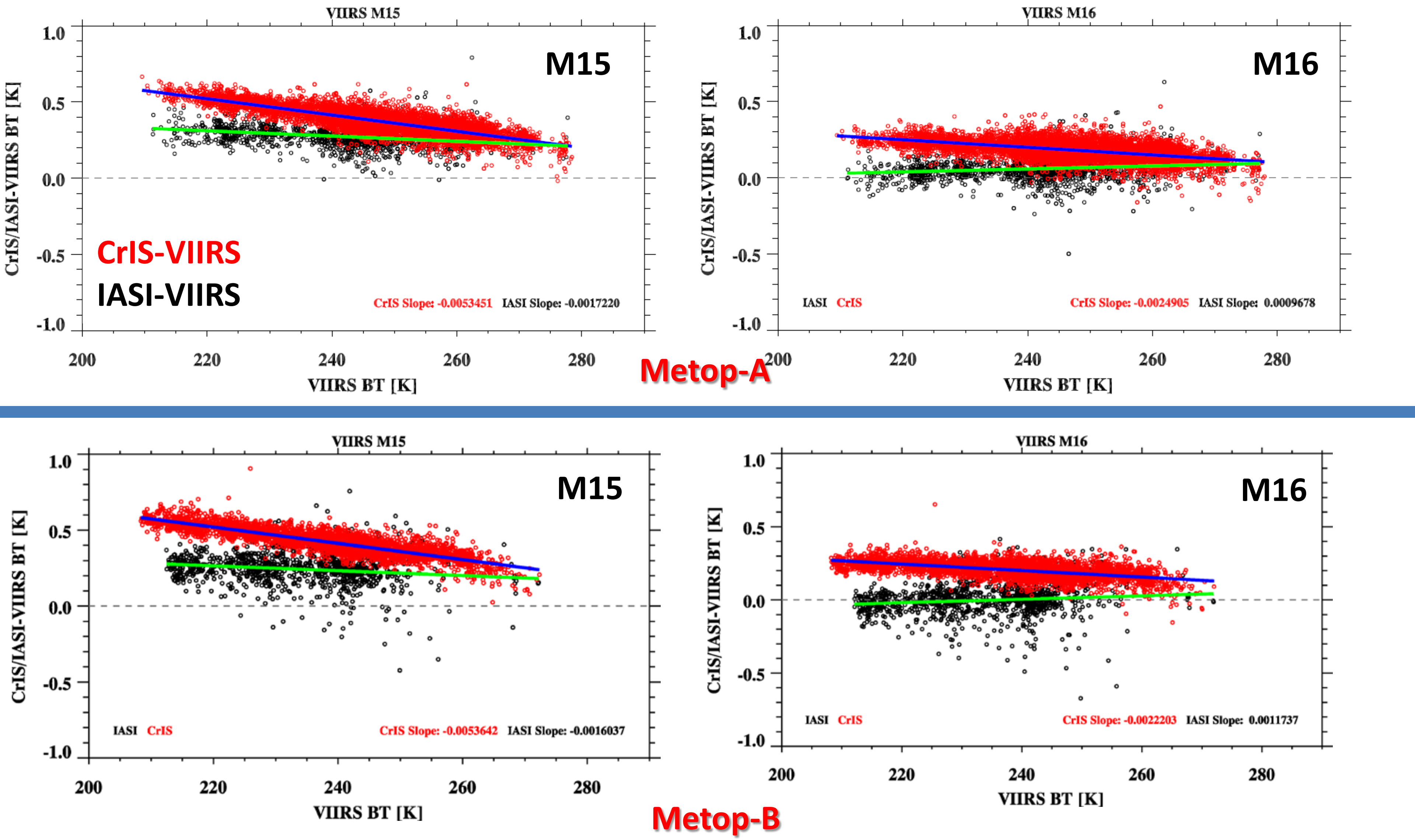




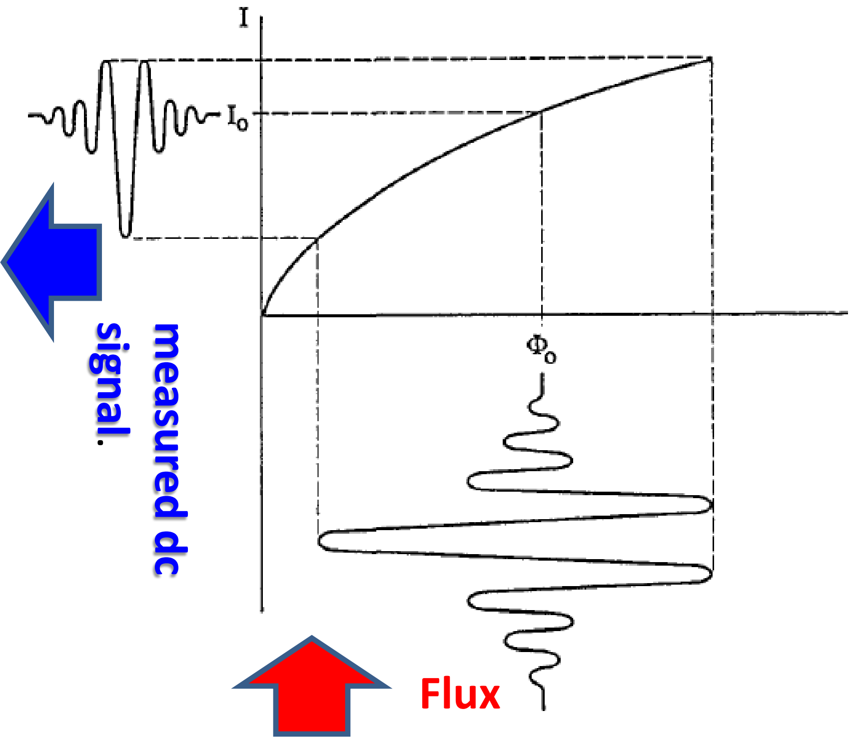


This relationship is used to compensate CrIS convolution results.

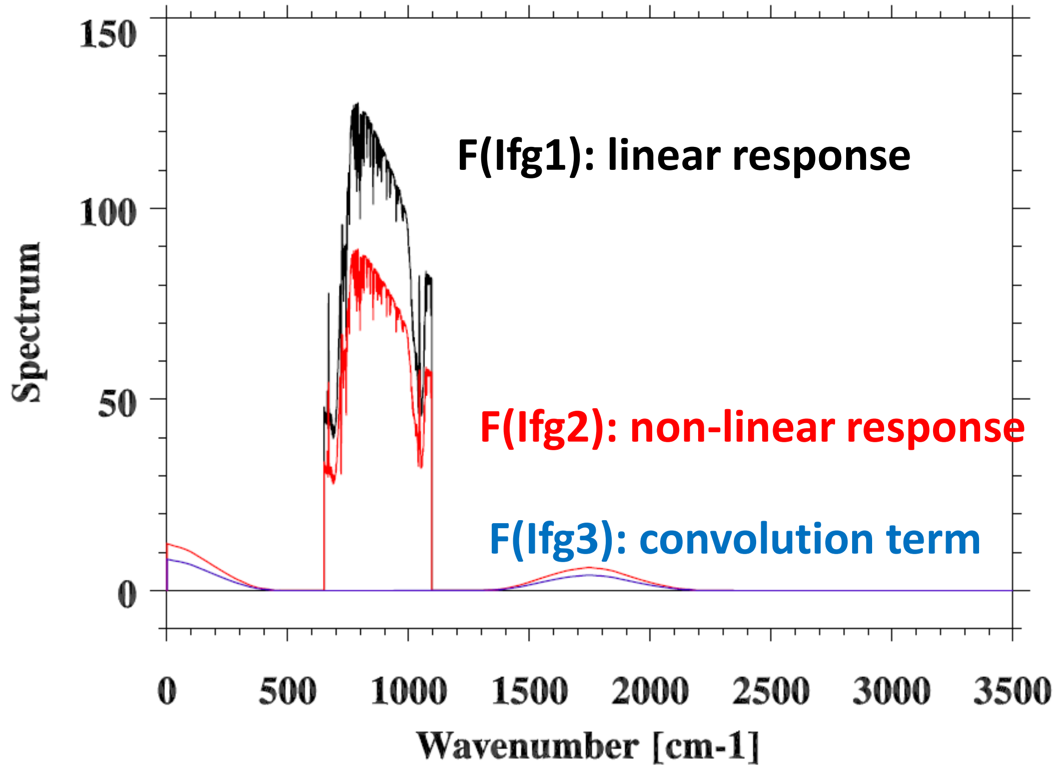
CrIS/IASI versus VIIRS



For a non-linear detector



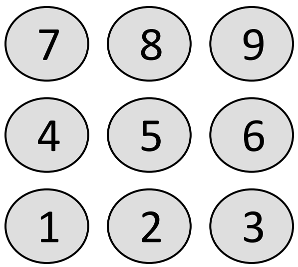
Hypothetical detector-response curve exhibiting nonlinearity. The horizontal axis represents the absolute magnitude of the photon flux and the vertical axis represents the measured dc signal.

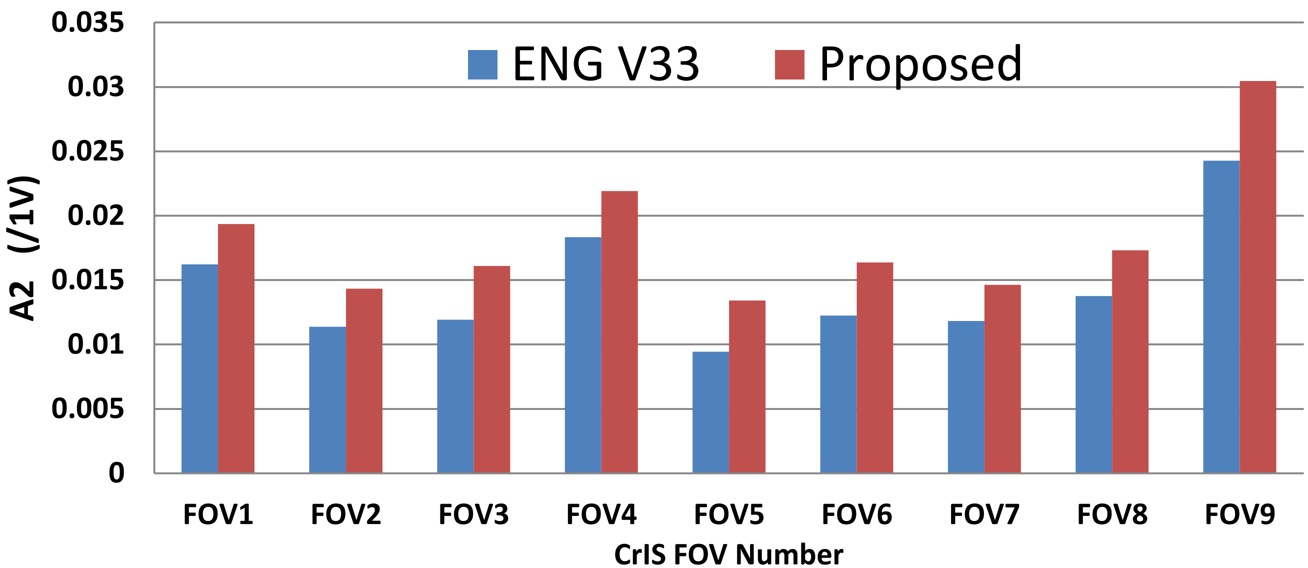


Non-linearity responses in spectral domain.

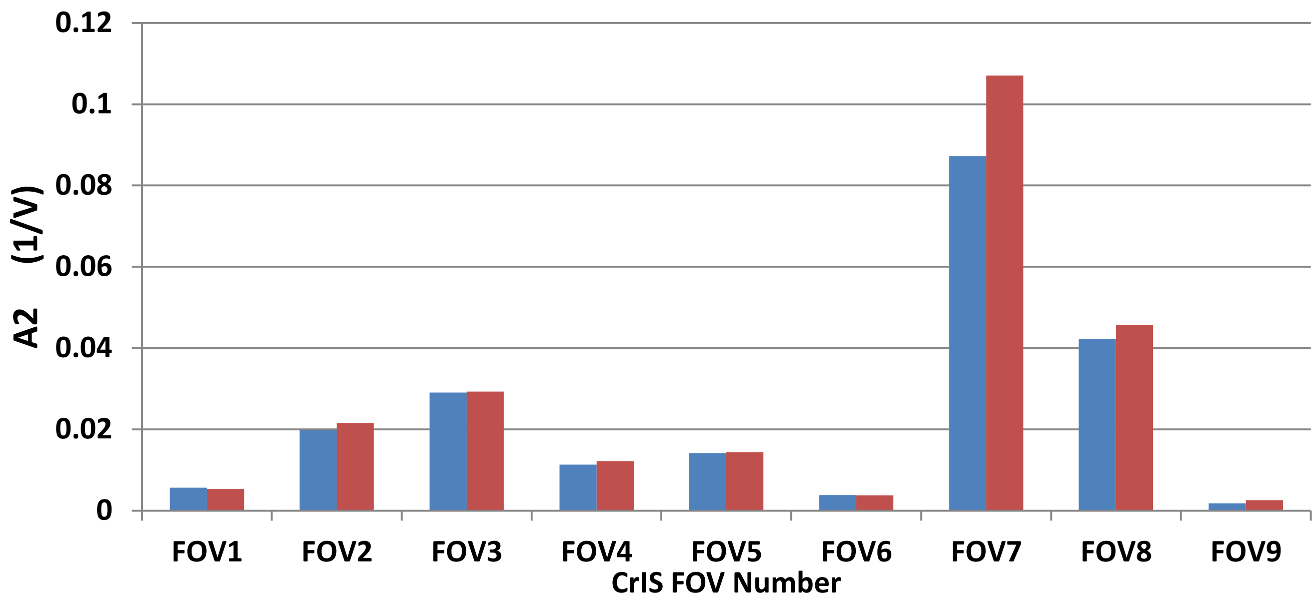
From Abrams et al. 1994

Non-linearity Coefficient Changes





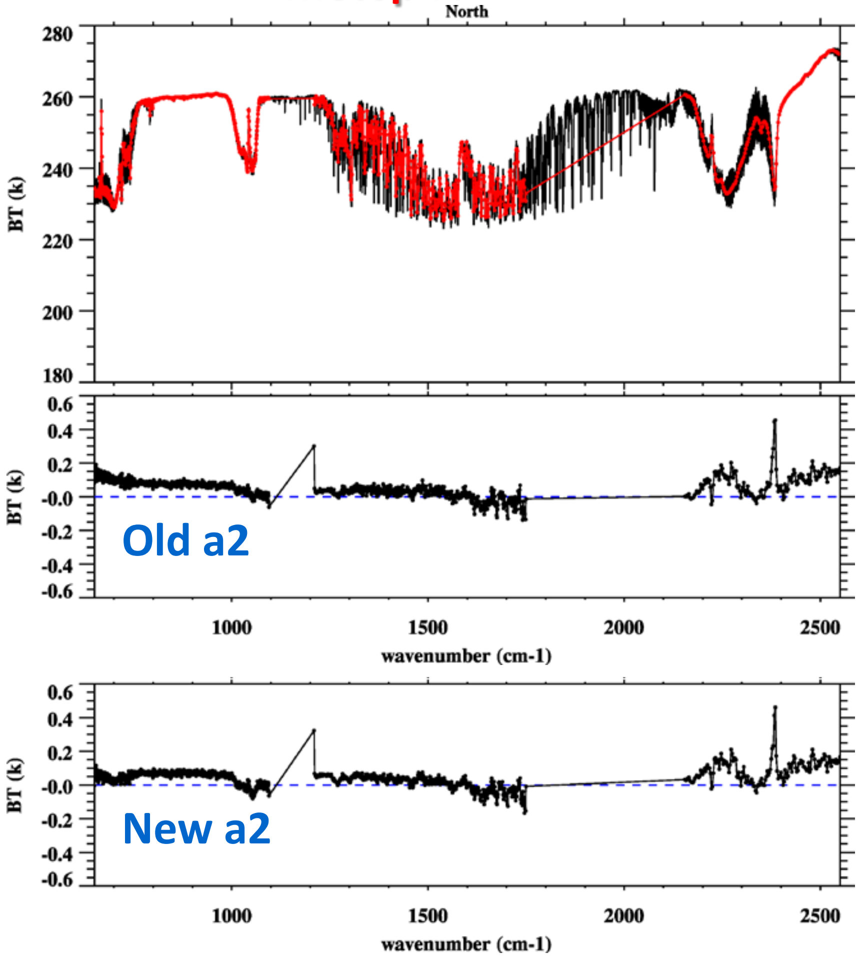
Longwave band



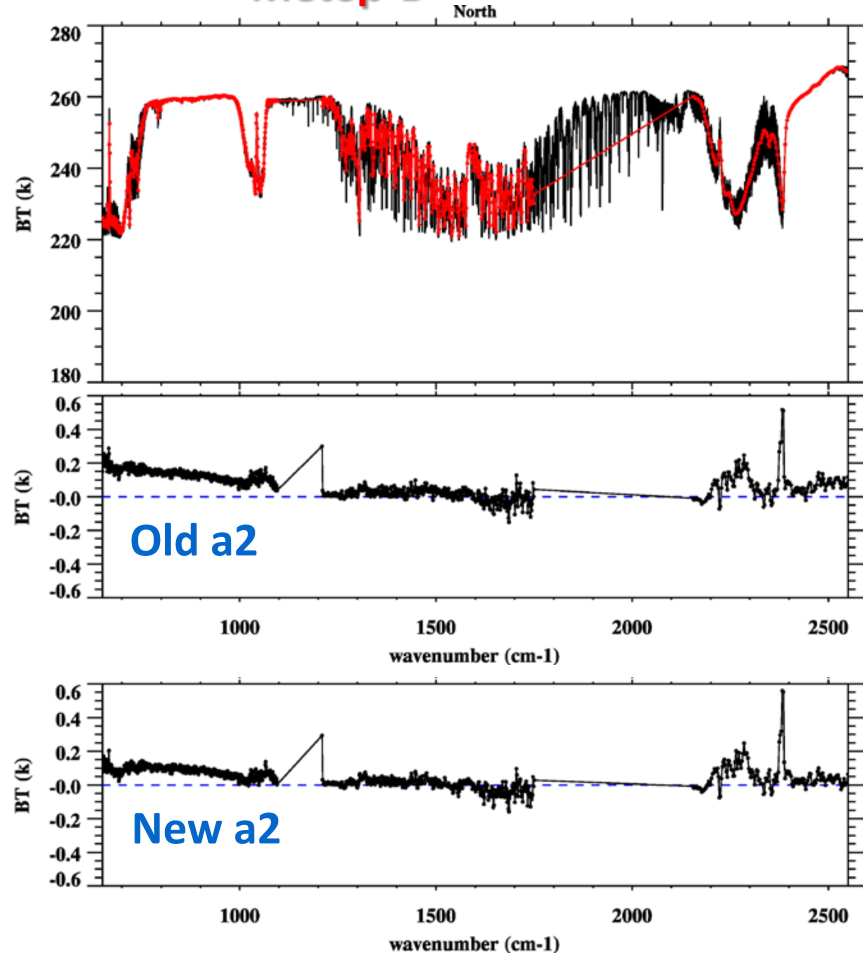
Middlewave band

BAND 1

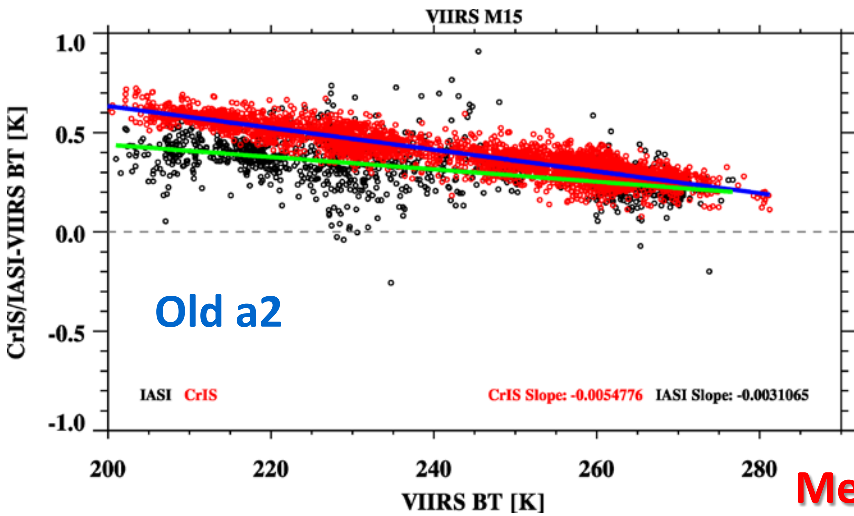
Metop-A

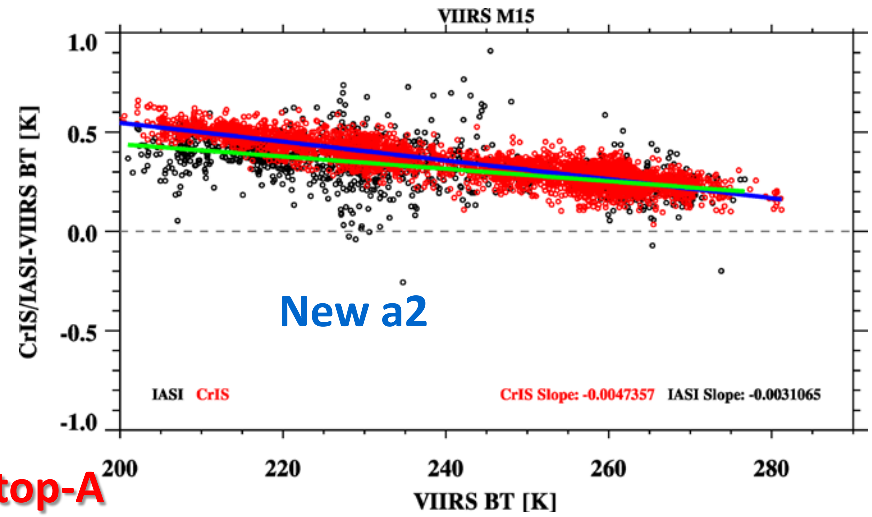


Metop-B

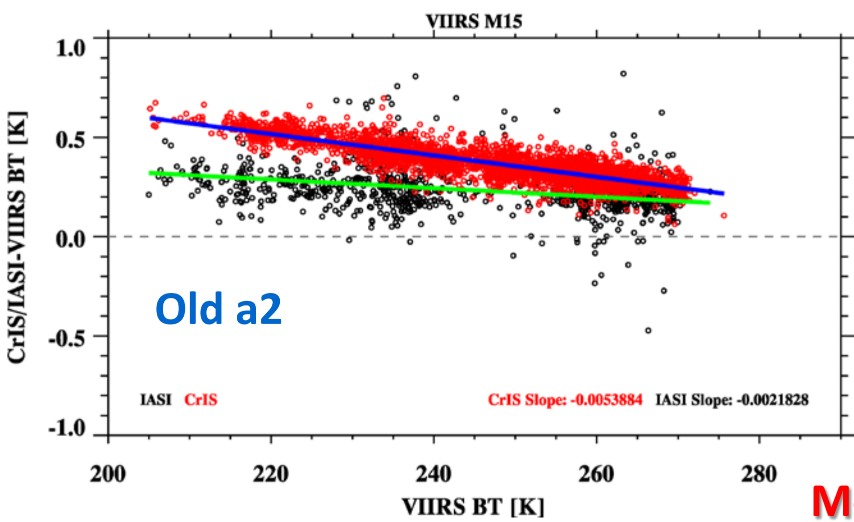


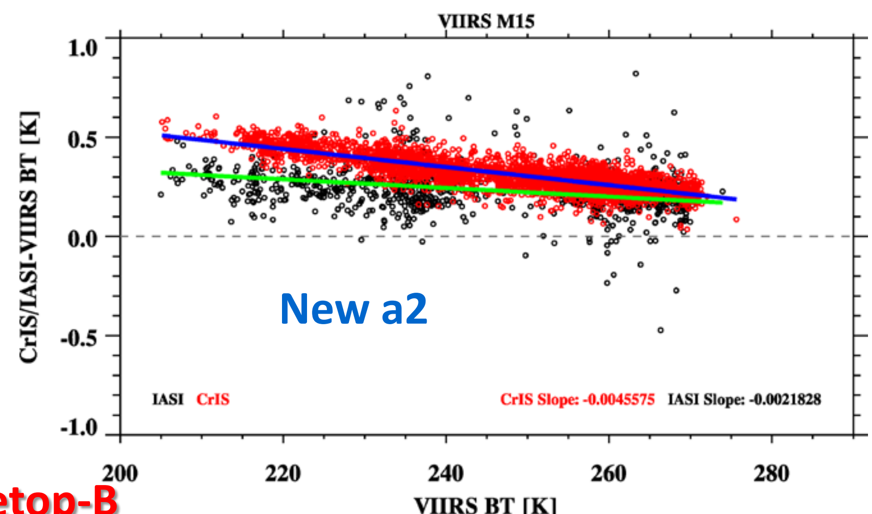
IASI/CrIS vs. VIIRS M15





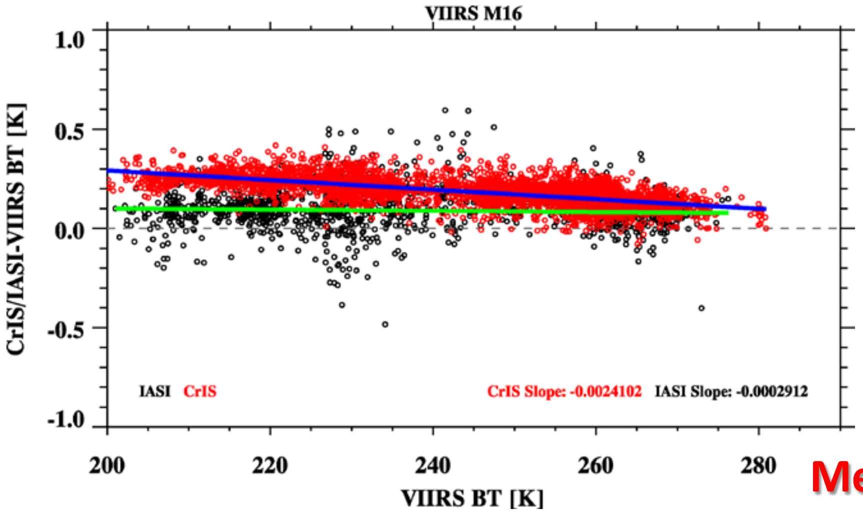
Metop-A

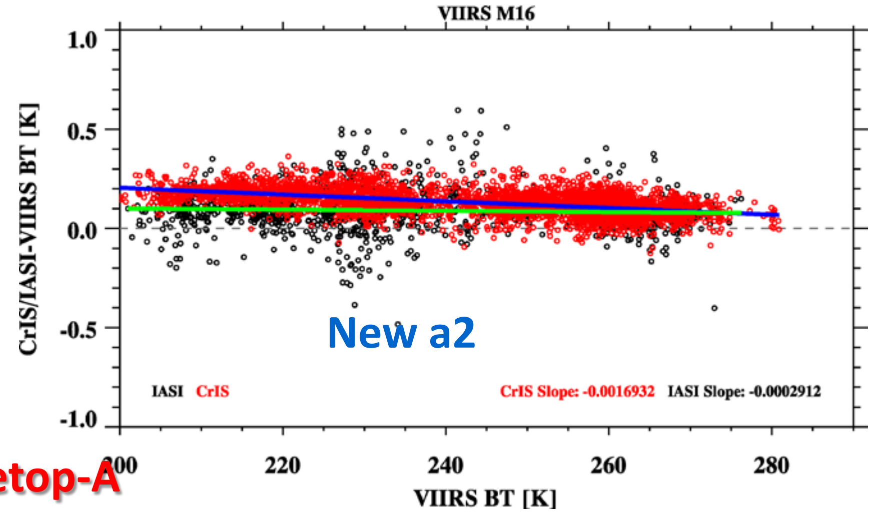




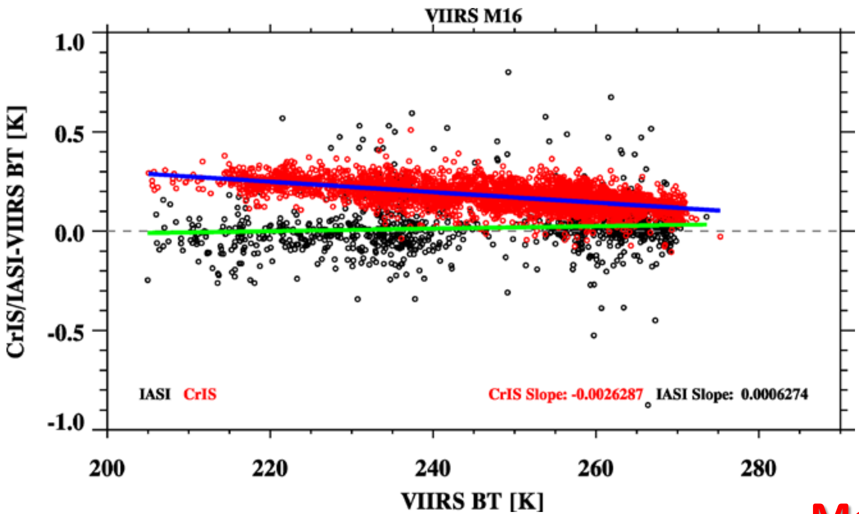
Metop-B

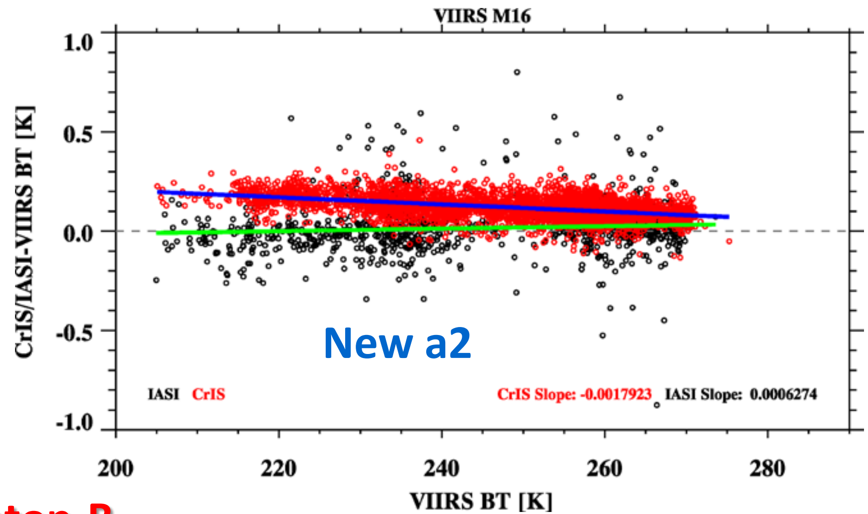
IASI/CrIS vs. VIIRS M16





Metop-A





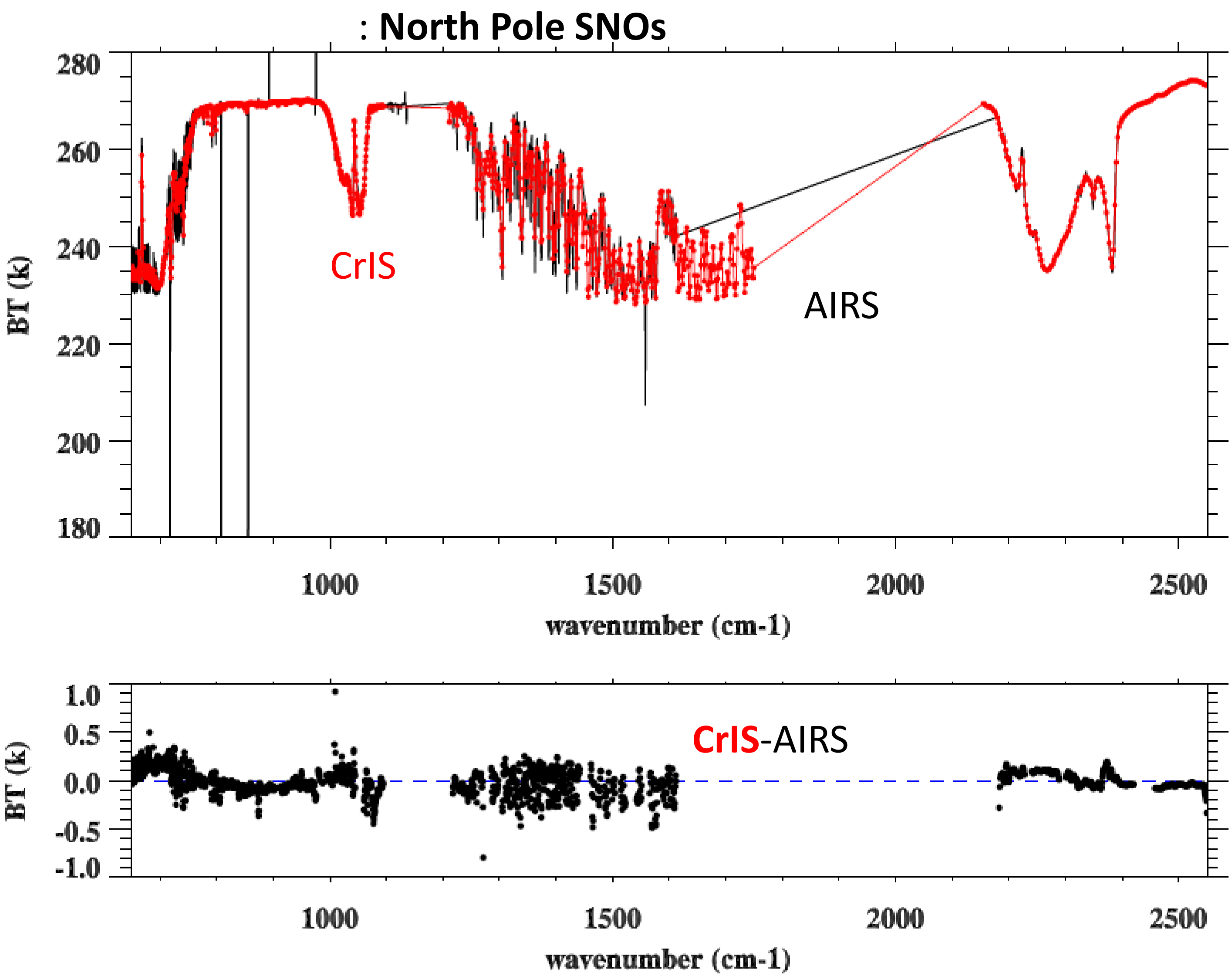
Metop-B

Conclusion

- Inter-comparison of CrIS with IASI indicate that the consistency between CrIS and IASI is around 0.1-0.2 K at most spectral regions.
  - Band 1: CrIS is warmer than IASI, especially for cold scenes
  - Band 2: CrIS and IASI agrees well at water vapor absorption region.
  - Band 3: Spectral inconsistency for shortwave sharp transition regions between CrIS and IASI
- CrIS/IASI vs. VIIRS band M15 and M16.
  - The differences are more apparent at cold scenes (180-200K) than at warm scenes (above 260K).
  - CrIS-VIIRS BT difference shows stronger scene-dependent features at M15 than IASI.
- The detector nonlinearity plays an important role for the differences among CrIS, IASI, and VIIRS.
- Newly-proposed nonlinear coefficients for CrIS will reduce the differences of CrIS-IASI and CrIS-VIIRS. After evaluation, these nonlinear coefficients will be released for operational data processing.

Thank you

AIRS vs. CrIS



: North Pole SNOs
280
260
240
220
200
180
BT (k)
CrIS
AIRS
1000
1500
2000
2500
wavenumber (cm-1)
1.0
0.5
0.0
-0.5
-1.0
BT (k)
CrIS-AIRS
1000
1500
2000
2500
wavenumber (cm-1)

BAND 1

MetOp-A

MetOp-B